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E. J. Stone, Esq., M.A., F.R.S., President, in the Chair.

Robert T. Pett, Esq., Royal Observatory, Cape of Good Hope,

was balloted for, and duly elected a Fellow of the Society.

Remarks on the Instructions for Observing the Transit of Venus formulated by the Paris International Conference. By Professor Simon Newcomb.

The recommendations of the Conference which met at Paris in October 1881 are entitled to such weight, both on account of the eminence of the astronomers who took part, and the advantages they naturally derived from mutual discussion, that I have hesitated in suggesting any possible improvement of their carefully-prepared instructions. This hesitation has been increased by the fact that my suggestions cannot now, as I should desire, be criticised by the Conference, to which I should have been glad to submit them. I submit them now to the Royal Astronomical Society with the hope that they will receive that critical discussion by all astronomers interested which alone can lead to a decision of all the questions involved.

The strongest reason for this course is, that as the entire Transit is visible on this continent, it is not improbable that the observations by astronomers in this country will exceed in number those made by the expeditions to be sent out by foreign Governments. The question whether American observers shall

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adopt the Instructions of the Conference unchanged is therefore an important one, which can be decided only by a careful examination and discussion of the subject. The following is to be regarded simply as my individual contribution to this discussion.

The Articles recommended by the Conference are found in the *Comptes Rendus* of the French Academy for October 17, 1881, tome xciii. p. 569.

The first three Articles call for little important remark, as they refer principally to the precautions to be taken by the observer; and I am unable to suggest any decided emendation. It may, however, be remarked that the use of the silvered objective might be inconvenient in the event of the Sun's rays being so obscured by smoke or haze that a deeply-coloured shade would be unnecessary. It might then be found that the silvering darkened the Sun's light too much.

In respect to Article III. I feel some doubt whether the degree of illumination of the solar disk is best defined by the distance apart at which two spider lines can be seen projected on the Sun. If, indeed, the amount of contrast between the brilliancy of the Sun and that of the atmosphere immediately around the limb were always the same—if, in fact, all the observations were made through a very transparent atmosphere, such a method of securing uniformity would perhaps be the best. But, in the actual observation of contact, everything depends upon the observer seeing the gradual approach or separation of the sharp cusps around *Venus*, and estimating the moment at which the thread of light becomes visible or invisible. Now, the greater the brilliancy, so long as the comfort of the eye is not interfered with, the more definitely, it would seem, must such phases as these be discriminated. It therefore appears to me that a better rule for regulating the brilliancy of the solar disk would be to make it as bright as the eye could bear with entire ease and comfort. To increase the precision of the observation, the Dawes solar eyepiece, cutting off all that portion of the Sun distant from the point of contact, might have been recommended.

In Article IV. we find the times of internal contact defined as follows:—

"*A l'entrée*: le moment où l'on voit pour la dernière fois une discontinuité bien évidente et en même temps persistante dans l'illumination du bord apparent du Soleil, près du point de contact avec *Vénus*.

"*A la sortie*: le moment de la première apparition d'une discontinuité bien marquée et persistante dans l'illumination du bord apparent du Soleil près du point de contact."

I confess to some difficulty in forming a precise conception of what should be understood by the phrase "illumination of the apparent limb of the Sun" and how "discontinuity" in that illumination should be noted. It may be that on actually

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observing the approach of a contact, it would be sufficiently clear to the observer what was meant. At the same time I deem it proper to point out the source of the apparent difficulty. To do this, and to discuss the subsequent explanations made by the Conference, I shall have to begin with some general statements respecting the phenomena of contact, founded partly on numerous observations of an artificial Transit of *Venus* in 1874, partly on the general description of the observers of that Transit, and partly on the reason of the case.

In doing this I may refer in passing to the paper in the *Monthly Notices* for March 1877 (vol. xxxvii. p. 237).

The moment of true internal contact is that at which the sharp points of the cusps begin to meet around the dark body of *Venus* as it enters upon the solar disk. Now, if the limb of the Sun presented itself to the vision as a distinct mathematical line, a discontinuity in which could be observed with geometrical precision, there would be no difficulty in the interpretation. As a matter of fact, however, it needs little consideration to show that no such definiteness is possible. The imperfections of vision in the eye, the instrument, and the atmosphere, all combine to render it impossible. The result is that, as *Venus* is approaching internal contact, it is impossible to fix the precise point at which the supposed sharp cusps terminate. To fix such points is very much like trying to fix the point where the tail of a comet terminates. The cusps can be traced further according to the sharpness of definition, the steadiness of the atmosphere, the keenness of the eye, and the habit of the observer.

The result is that there is no one moment at which all observers, even under the same conditions, would agree that contact had occurred.

The ends of the cusps assume a certain haziness, and the distance to which each cusp can be traced depends upon the relative brilliancy of the Sun's limb and of the atmosphere around it.

Moreover, owing to the effect of atmospheric tremors, the very sharp cusps, just before internal contact, are broken up and diffused in various ways. The result is that internal contact does not show itself by the completion of what can be recognised as the limb of the Sun, but by the gradual combination of the waving and ill-defined lines of light which form the cusps. Confining the attention to the space immediately behind the planet, the discontinuity of the limb is resolved into continuity by a slow and gradual process, the region along which contact occurs being occupied by a waving mixture of light and darkness as it were. During a period after internal contact, which varies from a few seconds to a minute, according to the circumstances of vision, the minute portion of the Sun's disk visible behind the planet is broken, and darkened by the effect of irradiation, atmospheric undulation, &c. Now, during this gradual process from complete discontinuity of the Sun's limb

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to complete continuity, extending over a period of perhaps an entire minute, how is the observer to say at any moment whether there is or is not "une discontinuité bien évidente"? Indeed, what should he consider a discontinuity?

This difficulty the instructions seek to resolve by describing more fully what the observer is to look for under different supposed conditions. To analyse these several instructions we must premise some further considerations respecting the character of the phenomenon.

I remark, first, that the manner in which dark appearances, such as the black drop, are very often spoken of, does not seem to be that most conducive to entire precision on the part of the observer. The only phenomena actually seen are those of greater or less degree of illumination, and darkness can only be predicated of those portions of the field of vision where there is no visible illumination. Darkness, in a word, is not visible.

As an application of these considerations I may say that the asserted presence of a black drop can mean nothing more than that the sharp cusps of *Venus*, instead of appearing sharp, as in their true form, appear rounded at their termini. May it not be, therefore, that precision would be gained if the observer's attention were confined to the phenomena of illumination exhibited by the cusps, and the black drop, or other forms of distortion, were described only as a blunting, rounding, or diffusion of the cusps?

Let us now take up the instructions in order:—

I. "Si les bords des deux astres viennent au contact géométrique sans déformation et sans obscurcissement du filet de lumière interposé, l'instant défini est celui même de ce contact."

This statement seems to me formulated with entire precision, and therefore does not call for further remark.

II. "S'il se produit une goutte noire ou ligament, bien net et aussi obscur que le corps même de la planète, les instants définis précédemment sont, à l'entrée celui de la rupture définitive, à la sortie celui de la première apparition du ligament."

I cannot but fear that in this case observers will note the time of ingress so much too late, and that of egress so much too early, as to destroy the value of their observations. All experience shows that there is no precise moment of rupture or formation of the ligament in such a case. Observers do, indeed, very often describe the formation as sudden, but, as is well known to all who have investigated the subject, the times they give for that sudden formation are so discordant that no weight can be assigned to it. In fact, as pointed out in the paper already referred to, if we suppose the planet approaching interior contact at egress, the band of light in front of it, as it grows thinner, appears darker to the vision from various optical causes too obvious to need enumeration. The amount of darkness is, however, uncertain, or, to speak with more precision, the brilliancy of the band as it fades away diminishes very gradually,

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until near the time of true contact, when the band is entirely lost to vision. Now, it would seem to be implied by the instructions that the moment to be noted was that of the first appearance of this darkening at egress, and, at ingress, that when it was about to disappear. To show the danger of such an interpretation I may advert to the observation of the Transit of 1874 made at Windsor, New South Wales, by Tebbutt, and published in the *Astronomische Nachrichten*, vol. lxxxv. s. 174.

It is evident from Mr. Tebbutt's description that he failed to observe either contact through waiting at ingress until almost every vestige of the ligament had disappeared, and at egress by endeavouring to catch its first formation.

III. "Si, les bords restant sans déformation, il se produit un obscurcissement du filet lumineux, sans que l'ombre devienne jamais aussi noire que le corps de la planète, l'observateur notera l'instant du contact géométrique. Il devra noter de plus l'instant de la formation ou de la disparition de l'ombre."

I only remark on the last sentence of this, that, as already explained, there can be no precise moment assigned at which the shade commences, nor do I clearly see how it can disappear otherwise than by becoming as dark as the body of the planet, a case supposed not to exist in the preceding sentence.

IV. "Si l'ombre interposée est d'abord ou devient aussi noire que le corps de la planète, l'instant défini précédemment est celui où cette égalité cesse ou celui où elle s'établit."

This definition of the time of contact concurs with the results of observations on the artificial Transit. But there seems room for question whether observers will in all cases be able to distinguish between this and the phenomenon described in II. It might be inferred, from the independence of the several definitions, that the Conference considered the phenomena of "l'ombre" and the "black drop" or "ligament" as distinct and separable. But there may be room for question whether this view can be sustained, and whether what is understood by the shadow is not simply the commencement or termination of what, when it becomes sufficiently marked, will be described as the black drop. Without, however, directly discussing this and the collateral question, I shall briefly indicate my views of the principles involved.

I. The great diversity of descriptions given by different observers arises as much from different ways of considering the phenomena as from differences among the actual phenomena. As a matter of fact, the character of the appearance is continually changing through the influence of atmospheric undulations, and one observer will catch and describe one appearance and one another. It is therefore essential to avoid merely subjective differences, that observers should have a clear idea of what they are to look for.

II. Assuming that the observations to be finally discussed will be made with sufficient optical power and with good

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instruments all set to focus, there will be but two principal sources of difference between actual phenomena. These are:—

a. Different degrees of atmospheric tremors or blurring.

b. Different degrees of contrast between the brilliancy of the Sun's limb and that of the atmosphere immediately adjoining it. The greater the irradiation produced by atmospheric tremors, and the greater the contrast between the brilliancy of the Sun and sky, the more decided may we expect to see that form of distortion commonly described as the black drop. In order to make all the observations comparable, we must seek out some phenomenon which shall be independent of these various conditions. This seems difficult unless the observer has himself a knowledge of the general theory of the subject so that he will know how to make the best estimate under any conditions.

III. Observations of the artificial Transit, made so as to imitate as nearly as possible the appearance of the actual Transit, seem to indicate that the only moment which remains nearly the same under all circumstances is to be estimated by confining the attention to the cusps of light and the general outline of the Sun and planet near the time of contact. If the contrast between the brilliancy of the Sun and sky is considerable, the moment of true contact at ingress is that when light is about to glimmer all the way across the dark space between the cusps. The first glimmer may, however, be a fine line of light, a general haziness, or a confused mixture of luminous filaments covering a considerable breath, according to the distinctness of vision and the steadiness of the atmosphere. Very generally there will be a period of several seconds during which the light will glimmer and disappear by turns. The middle of this period is that of the true contact.

IV. If, owing to haze, smoke, or clouds, the contrast between the brilliancy of the Sun and of the sky is much less than usual, it may be that the actual completion of the thread of light cannot be noted for some seconds after true contact at ingress, but the practised observer will still be able, by estimation, to say when the cusps should have met had they been brilliant and therefore sharply defined. The appearance to be noted is not that of supposed geometrical tangency, a moment which cannot be estimated with any precision whatever, and is substantially valueless, but a moment defined by a general estimate for which no precise directions can be given, and of which the eye itself is a good judge. If in lieu of the first sentence of Article V. of the instructions we should direct the observer to prolong the cusps around *Venus* "*par la pensée*," and note the moment when the cusps thus prolonged should meet, it would accord closely with the view here indicated.

V. I should regret to have exterior contacts neglected until we have some better evidence than has yet been furnished that they are not as accurate as interior contacts.

VI. One disturbing circumstance which might frequently